Evaluation of Stream Bottom Fauna Sampling Techniques as used in the Logan River

Donald C. Hales

Utah State University

EVALUATION OF STREAM BOTTOM FAUNA SAMPLING TECHNIQUES AS USED IN THE LOGAN RIVER

DONALD C. HALES

1955

UTAH STATE AGRICULTURAL COLLEGE

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EVALUATION OF STREAM BOTTOM FAUNA SAMPLING TECHNIQUES

AS USED IN THE LOGAN RIVER

by

Donald C. Hales

A thesis submitted in partial fulfillment
of the requirements for the degree

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Approved:

W. F. Sigler

Major Professor

W. F. Sigler

Head of Department

Stewart Williams

Dean of Graduate School

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Frontispiece - Aerial view of lower Logan Canyon, a portion of a U. S. Air Force photograph taken from 43,000 feet altitude. Temple Fork is on the extreme right front.

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INTRODUCTION

Importance of the problem

Since the square-foot bottom sampler was described by Surber (1937) it has been the principle[1] instrument used for quantitative studies of the bottom fauna in riffle areas of streams. However, little has been written concerning the actual number of square-foot samples necessary to describe stream bottom fauna in terms of the number or volume of organisms.

Taking bottom samples requires considerable time and money. Each of the samples taken for this study required from 30 to 45 minutes to separate, count, and measure volume. Separation of samples into individual groups took from one to two hours. At $10.00 per man day, it would cost considerable more to separate each Order of organisms to number and volume.

Within a short time interval the species composition, numbers and volumes of organisms may change. This makes the describing of a stream within a short time imperative. From the economic standpoint and the rapid change in composition of organisms in the stream, it is necessary to know the minimum number of square-foot samples that will adequately describe the bottom fauna. The biologist must decide the degree of accuracy he wishes his description to have. It is understood that the same number of samples may not be necessary at any two stations or even the same station at different times. However, there is a minimum number of samples that adequately describes the bottom at any time or station. The object of this study is to determine that number.

Review of literature

Most literature concerning bottom fauna sampling gives no idea as to the number of samples necessary to adequately describe a stream within prescribed limits. Allen (1941) states, "Sufficient samples should be taken to permit a reasonably accurate mean fauna to be determined, and that all environments occuring in the waters studied should be proportionately represented." According to Pennack and Van Gerpin (1947), a survey should be based on an adequate number of samples taken from all substrates present, and in relative percentages to these substrates. Henderson (1949) used the square-foot sampler to determine the number and weight of organisms in a pollution study with no statistical basis for his conclusions. Hess and Swartz (1941) suggest that sufficient samples be taken to keep the standard error within 10 percent of the mean.

Surber (1937) shows a mean deviation from the mean as low as 26.2 percent for samples of Gammarus. Leonard (1939) shows satisfactory accuracy as to the total volume of organisms present on a gravel bed of approximately 110 square feet.

The only economically impractical results found in the writer's review of literature was that of Usinger and Needham (1954). They say that it would require 194 square-foot samples to give significant numbers at a 95 percent confidence level for the total volume, and 73 samples for the total number of organisms.

GENERAL DESCRIPTION OF LOGAN RIVER DRAINAGE

Location

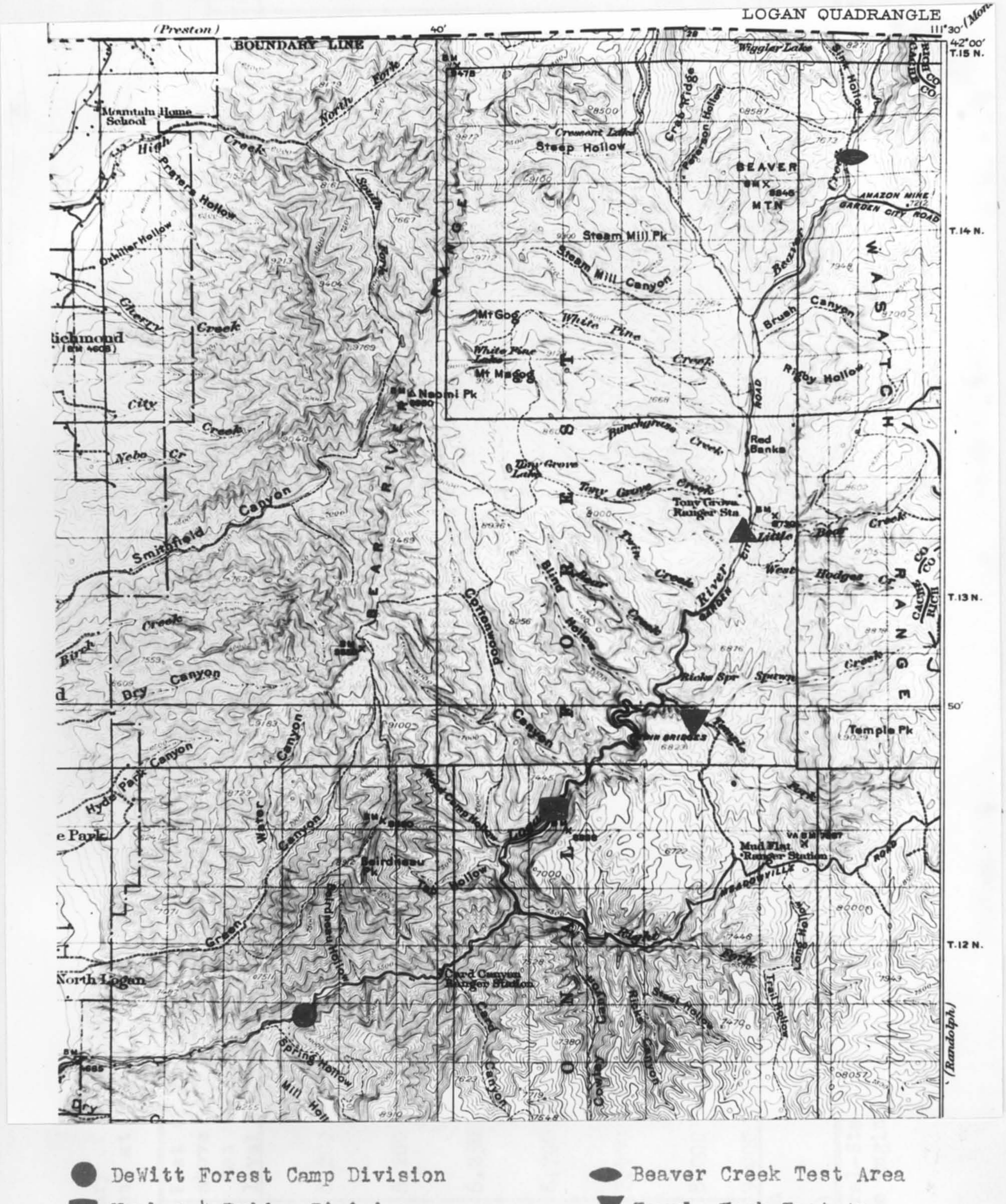
Study areas are located in Logan River and two of its tributaries, Temple Fork and Beaver Creek, in Cache National Forest, northern Utah (Figure 1). Logan River begins in Franklin County, Idaho. It enters Utah at 8,500 feet elevation. It flows southwesterly through Logan Canyon for approximately 26 miles, entering Cache Valley at 4,700 feet. It then turns northward and meanders until it joins Bear River. The latter empties into Great Salt Lake.

Geology

The Bear River Range, which is the drainage area for Logan River and several other streams, is made up largely of limestone and dolomite of Paleozoic origin. Williams (1948) states, "The Bear River Range, at least in the Logan quadrangle, consists essentially of two tilted blocks bounded by the same type of faults." The range, according to Williams, is comprised of two ridges separated by a depression. The higher western ridge or Front Ridge is the elevated western edge of a fault block bounded by the East Cache Faults. The eastern ridge is composed of Temple and Hayes Ridges, and is bounded by faults of the same name. Both the eastern and western ridges are of similar structure. Upper Logan River is in the northern part of the asymetrical depression.

Climate

The higher sections of the study area have approximately 30 inches of precipitation per year (Cook and Harris, 1950). The average snow depth, measured on seven stations located at elevations from 6,250 feet to 9,000 feet, is 61.5 inches in April when the snow is deepest. This



● DeWitt Forest Camp Division

■ Number 4 Bridge Division

▲ Tony Grove Summer Camp Division

⬬ Beaver Creek Test Area

▼ Temple Fork Test Area

Figure 1. Logan River drainage, section of Logan Quadrangle, showing sampling stations.

Table 1. Summary of snow surveys, 1924-54, for Logan River Drainage with average inches of snow and water present at the time of survey*

Snow Course	Feet above sea level	January			February			March			April			May		
		Snow in.	Water in.	No. of years	Snow in.	Water in.	No. of years	Snow in.	Water in.	No. of years	Snow in.	Water in.	No. of years	Snow in.	Water in.	No. of years
Franklin Basin Ranger Station	8,200	35.6	9.9	2	52.2	16.1	1	70.0	24.4	4	71.1	24.4	30			
Tony Grove Lake	8,200	43.6	12.5	4	52.8	16.2	4	73.3	24.7	4	85.6	24.7	28			
Tony Grove Ranger Station	6,250	18.2	4.0	3	29.2	7.2	6	32.0	10.5	6	23.9	8.9	28			
Mud Flat Ranger Station	6,700										24.7	10.2	8			
Spring Hollow (Lower)	7,000	24.5	5.6	28	35.2	9.2	30	41.0	12.9							
Spring Hollow (Upper)	8,000	38.3	9.0	30	55.1	14.3	30	65.8	19.7	29	40.5	14.1	30	16.3	6.8	16
Mt. Logan	9,000	40.3	10.5	30	57.4	17.3	30	70.5	23.6	30	80.6	29.5	30	63.5	27.7	27
Ave. Snow Depth of Drainage (Weighted Ave.)		22.0	8.5		48.2	13.5		58.7	18.8		61.5	22.6		51.5	21.7	

*From the Federal-State Cooperative Snow Surveys, Summary for Utah, 1924-54, issued by the U. S. Soil Conservation Service, State Engineer, and the Utah Agricultural Experiment Station.

is 22.6 inches of water. Logan, Utah, (4,500 feet elevation) receives about 16 inches of precipitation annually.

Logan, Utah, has an average January temperature of 24.3° F. and an average July temperature of 73.1° F., based on a 40-year record (1941). The stream study areas are located at 5,050, 5,500, and 6,300 feet elevation.

Hydrography

Logan River is largely riffles which range from smooth to torrential. There is nearly a complete lack of pools. The average gradient is 70 feet per mile with a maximum of 176 feet per mile and a minimum of 30 feet per mile. Temple Fork and Beaver Creek, tributaries to Logan River, have a gradient of approximately 208 and 200 feet per mile, respectively. The summer average depth for Logan River is approximately 0.7 feet. The average velocity for the river is 2.6 feet per second for readings taken at a series of stations from April to October in 1948 and 1949 (Sigler, 1951).

According to Fleener (1951), the water temperature from April to October ranges from 37° F. to 56° F., and rarely exceeds 48° F. In the summer camp area, December 4, 1953, the temperature was 31° F., and ice was formed on the rocks on the bottom (Figure 1). Turbidities, based on silicon oxide equivalents, range from 25 to 32 parts per million in the spring to six to eight parts per million in the fall (Sigler, 1951). Silting is slight except during the spring runoff, this being the only sign of pollution.

From a water sample taken two miles above the mouth of Logan Canyon, July 26, 1949, Sigler (1951) obtained the following results in parts per million: total dissolved solids, 210; calcium, 42; magnesium, 14;

Table 2. Mean discharge in cubic feet per second of Logan River at the mouth of Logan Canyon

Month	1946	1947	1948	1949	1950	1951	1952	1953	1954	Monthly Mean
January		115	106	114	125	139	128	127	111	121
February		115	102	108	120	146	117	116	104	116
March		138	98	124	140	143	115	121	112	124
April		215	226	312	367	458	337	196	210	290
May		692	763	697	799	824	865	352	458	681
June		503	776	557	1,156	776	772	704	291	692
July		280	343	298	651	403	366	357	197	362
August		203	227	211	322	262	246	220	139	229
September		164	182	182	241	208	198	171	115	183
October	170	145	161	170	204	188	172	149		170
November	149	128	142	135	185	163	151	137		149
December	132	115	125	121	161	142	135	118		131
Year Mean	150	234	271	252	373	321	300	231	193	
Ave. Daily Discharge	-	-	-	-	-	-	-	-	-	271

Data from M. T. Wilson, District Engineer, U. S. Geological Survey.
A. B. Harris, Engineer in charge Logan Office, U. S. Geological Survey.

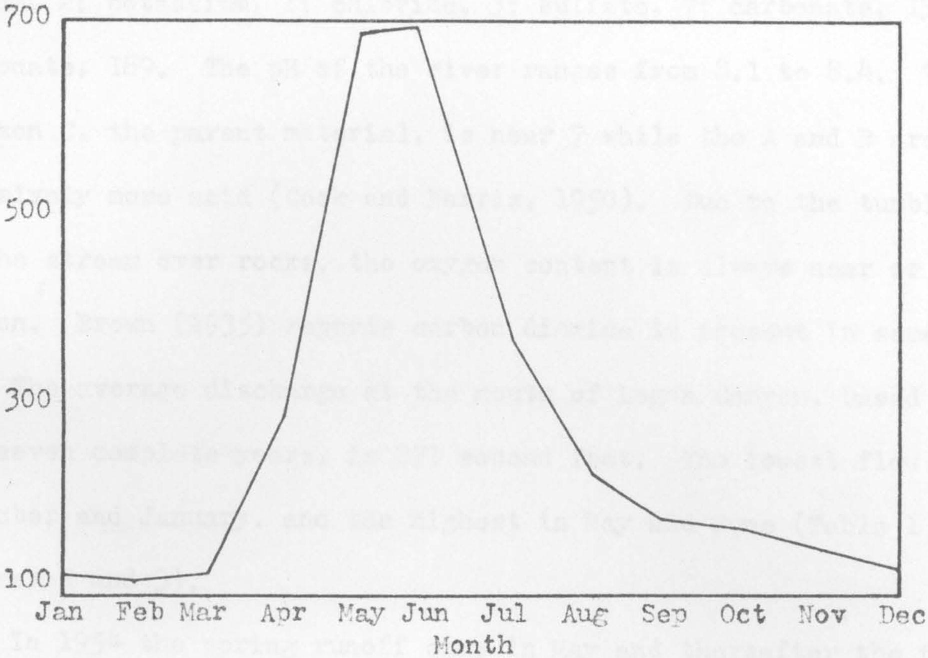


Figure 2. Mean monthly discharge in cubic feet per second of Logan River, calendar years 1946-1954.

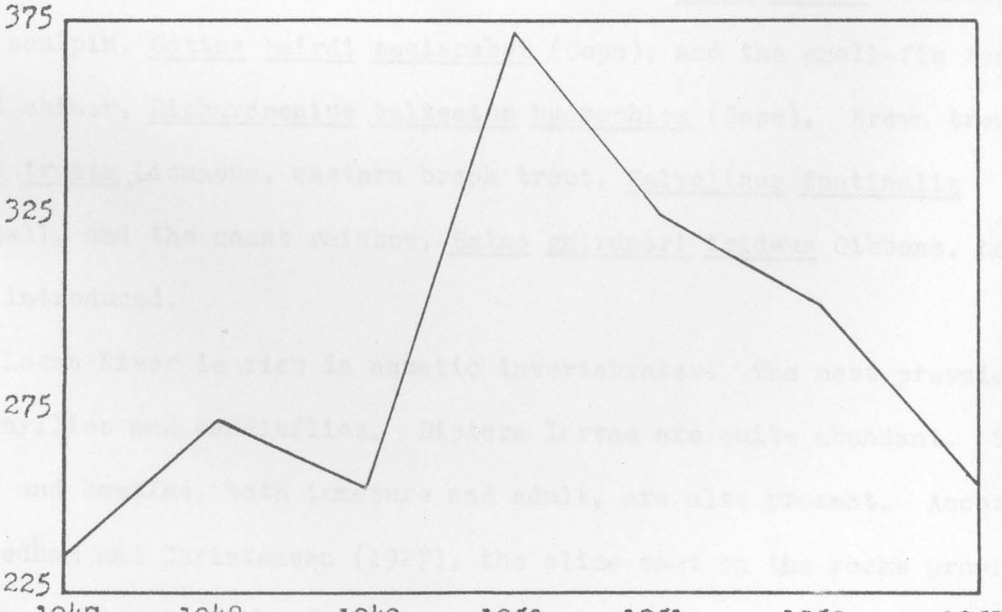


Figure 3. Mean yearly discharge in cubic feet per second of Logan River, 1947-1953.

sodium, 2; potassium, 1; chloride, 3; sulfate, 7; carbonate, 13; bicarbonate, 189. The pH of the river ranges from 8.1 to 8.4. The soil horizon C, the parent material, is near 7 while the A and B are progressively more acid (Cook and Harris, 1950). Due to the tumbling action of the stream over rocks, the oxygen content is always near or at saturation. Brown (1935) reports carbon dioxide is present in some springs.

The average discharge at the mouth of Logan Canyon, based on records for seven complete years, is 271 second feet. The lowest flow occurs in December and January, and the highest in May and June (Table 1 and Figures 2 and 3).

In 1954 the spring runoff came in May and thereafter the flow was much less than in other years.

Habitat

Logan River has four species of native fish: mountain whitefish, Coregonus williamsoni Girard; cutthroat trout, Salmo clarki Richardson; Utah sculpin, Cottus bairdi semiscaber (Cope); and the small-fin red sided shiner, Richardsonius balteatus hydrophlox (Cope). Brown trout, Salmo trutta Linnaeus, eastern brook trout, Salvelinus fontinalis Mitchell, and the coast rainbow, Salmo gairdneri irideus Gibbons, have been introduced.

Logan River is rich in aquatic invertebrates. The most prevalent are mayflies and caddisflies. Diptera larvae are quite abundant. Stoneflies and beetles, both immature and adult, are also present. According to Needham and Christensen (1927), the slime coat on the rocks provides the greater part of the food for the invertebrate herbivores.

Watershed

The low amount of siltation present in Logan River indicates that

Cache National Forest is one of the better managed watersheds in Utah. The vegetation on the north-facing slopes is largely aspen, _Populus tremuloides_ Michx., and Douglas fir, _Psuedotsuga menziesii_ (Mirb.) Franco. Patches of bigtooth maple, _Acer grandidentatum_ Nutt. are scattered in between.

On the south-facing slopes, Utah juniper, _Juniperus utahensis_ (Engelm.) Lemm. and sage brush, _Artemesia tridentata_ Nutt., are dominant. Big-tooth maple is found in gullies and protected areas. Mountain mahogany, _Cercocarpus ledifolius_ Nutt., may be found locally in the higher areas and also on the north-facing slope near the mouth of the canyon.

PROCEDURE

Three divisions were laid out in the following areas in Logan River: (1) Tony Grove Summer Camp, (2) Number 4 Bridge, and (3) at the east end of DeWitt Forest Camp.

Each division is composed of 50 experimental units. Each experimental unit is divided into 10 three-foot-square sampling sections (Figure 2). In placing an experimental unit, uniformity of water depth and current were primary objectives. At the summer camp division the experimental units were more or less scattered throughout the 1,700 feet of river to obtain these conditions. However, in the other two divisions the stream is somewhat more uniform throughout, and nearly all of the units are adjacent to each other.

For sampling within a division, experimental units were selected at random. The sampling section where the samples were taken was also drawn at random from within the experimental unit. All samples were taken with a square-foot sampler similar to that described by Surber (1937).

In the colder months samples were placed in wide-mouth quart jars and taken to the laboratory for analysis. During the warmer months samples were analyzed in the field. Volumes of organisms were measured by the water displacement method in a centrifuge tube calibrated to 0.1 of a cubic centimeter. Excess moisture was removed from the organisms by placing them on tissue paper for a short period of time.

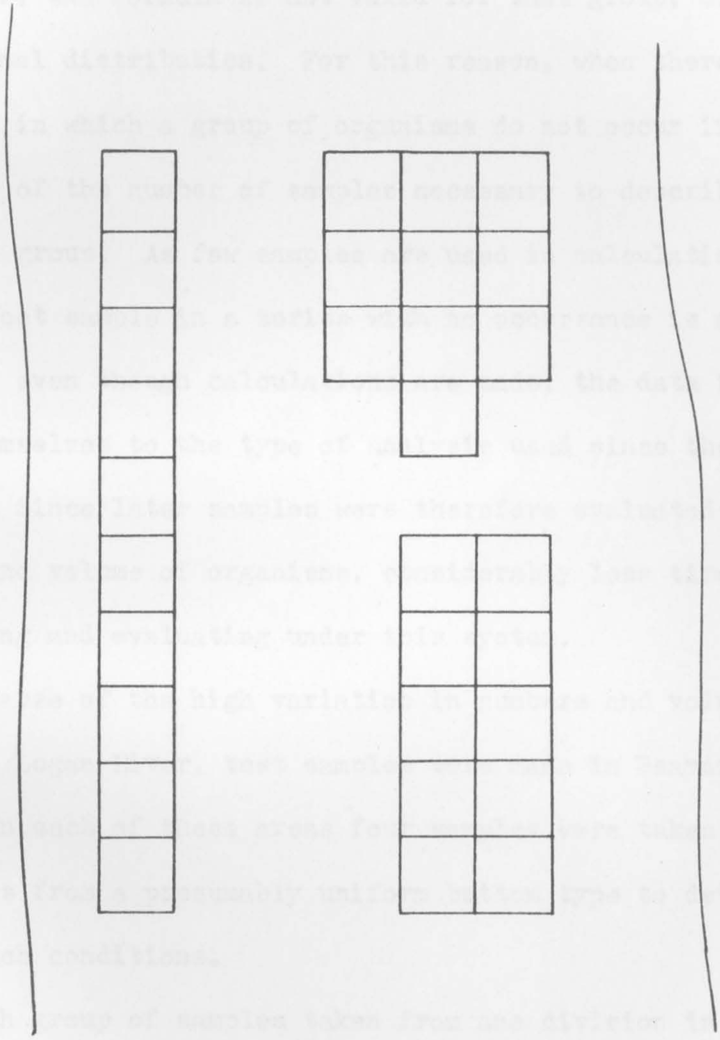


Figure 4. Designs of experimental units as laid out within stream divisions.

At first, attempts were made to statistically evaluate each order of insects. Less common organisms, such as Arachnida and Oligochaeta, were listed to Class. However, some groups of organisms did not show up in every sample. When samples of a set do not contain a group of organisms, the formula is not valid for that group, since it is based on a normal distribution. For this reason, when there is more than one occasion in which a group of organisms do not occur in a series, no estimate of the number of samples necessary to describe the mean is made for that group. As few samples are used in calculations, this one square-foot sample in a series with no occurrence is arbitrarily chosen. Further, even though calculations are made, the data for groups may not lend themselves to the type of analysis used since they are often skewed. Since later samples were therefore evaluated only to total number and volume of organisms, considerably less time was involved in separating and evaluating under this system.

Because of the high variation in numbers and volumes of organisms found in Logan River, test samples were made in Beaver Creek and Temple Fork. In each of these areas four samples were taken in adjacent positions from a presumably uniform bottom type to determine variation under such conditions.

Each group of samples taken from one division in one day was analyzed to determine the mean number of organisms per sample, the variance, the standard deviation, and the number of samples necessary to describe the mean of the bottom fauna of a division. The calculated number of samples describes the mean with prescribed limits of accuracy with the risk of being wrong a certain fraction of the time.

General formulas used in analyses are:

1. $s^2 = \dfrac{\Sigma X^2 - (\Sigma X)^2/n}{n-1}$

2. $\overline{X} = X/n$

where:

s^2 is the variance.

X is the number or volume of organisms in one square-foot sample.

n is the number of square-foot samples used in calculations.

$\overline{X}$ is the mean of the number or the volume of organisms in the set of n samples.

3. $\sqrt{N_1} = s/.05(\overline{X})$

where:

N_1 is the number of samples necessary to describe the mean within $\pm$ 5 percent with the risk of being wrong 1/3 of the time (assuming N_1 turns out to be large).

s is the standard deviation.

4. $\sqrt{N_2} = s/.1(\overline{X})$

where:

N_2 is the number of samples necessary to describe the mean within $\pm$ 10 percent with the risk of being wrong 1/3 of the time (assuming N_2 is large).

5. $\sqrt{N_3} = 1.7\ (s)\ /.25(\overline{X})$

where:

N_3 is the number of samples necessary to describe the mean within $\pm$ 25 percent with the risk of being wrong 1/10 of the time (assuming N_3 is greater than 15 to 20).

6. $\sqrt{N_4} = 1.7\ (s)\ /.5(\overline{X})$

where:

N_4 is the number of samples necessary to describe the mean within $\pm$ 50 percent with the risk of being wrong 1/10 of the time (assuming N_4 is greater than 15 to 20).

The formulas for N_1, N_2, N_3, and N_4 are based on the formula:

$$\sqrt{N} = \frac{ts}{a(\bar{X})} \quad \text{where:}$$

t is the approximate value for a given risk taken from a standard table for the percentage points of the t-distribution.

a is the given percent of accuracy desired in describing the mean.

When the calculated N values from the above formulas fell below 10, they were recalculated, using a t value that gave a more accurate value of N. When the sample size falls below this number, the t value is significantly higher than that used in the above formulas. It should be understood that these values of N are approximate. Further, values of 3 or below should be viewed with suspicion.

The sample sizes upon which estimates of variance (s^2) are based are small in all cases. This introduces a tremendous error in the estimated number of samples required for the various levels of accuracy. However, these estimates are the best obtainable.

A transect of 100 feet was run in each division to estimate bottom types. This estimate and a classification of bottom types is given in Table 3.

DESCRIPTION OF DIVISIONS AND SAMPLING AREAS

Tony Grove Summer Camp

This station begins at the summer camp bridge and extends downstream about 1,700 feet (Figure 1). Within the division are several stream improvement dams. These did not lend themselves to sampling, however. The stream in this area ranges from 25 to 60 feet in width. There is approximately one foot fall in every 100 feet. Bottom type is largely boulders and coarse rubble (Table 3). Many boulders are from two to three feet in diameter. The experimental units were laid out in such a way as to miss these large boulders. Fine rubble is sometimes present between the boulders and coarse rubble. The rough terrain made sampling difficult, as the sampler could not always be placed flat on the bottom. This is, no doubt, one cause for the high variation.

The depth of the water ranges from one to 18 inches except in May and June when run-off is high.

Number 4 Bridge

This division begins about 100 feet downstream from the bridge (Figure 1). It extends downstream 150 feet. The stream is 45 to 50 feet wide with a fall of approximately one foot in 150 feet. Bottom type is largely rubble with some boulders present but not to the extent occurring at the summer camp division. The rocks in this area are "blocky" while those in the summer camp area are rounded and worn.

The depth ranges from six to 18 inches and the water is rapid.

DeWitt Forest Camp

The DeWitt division is located immediately south of Logan City

Figure 5. Tony Grove Summer Camp Division, Logan River, June 29, 1954.

Figure 6. Tony Grove Summer Camp Division, Logan River, August 1954.

Figure 7. Number 4 Bridge Division, Logan River, June 20, 1954.

Figure 8. DeWitt Forest Camp Division, Logan River, June 20, 1954.

water supply spring. The station is 120 feet in length. There is approximately six inches fall in the division. The depth is from nine to 30 inches. The bottom type is largely fine rubble and gravel. Few boulders are present in the area. The water is swift.

Temple Fork and Beaver Creek test areas

In Temple Fork and Beaver Creek test areas there is uniformity in the bottom characteristics. In Temple Fork three tests were made in different areas. In areas number one and two the bottom type is fine rubble. In number three area the bottom type is gravel. The depth in all three areas is three to four inches.

In the Beaver Creek area the bottom type is gravel. The depth is five to six inches.

Each of these areas was used to determine the variation found when samples are taken adjacent to each other.

Figure 9. Beaver Creek test area, Beaver Creek, a tributary to Logan River, July 1954.

Figure 10. Temple Fork, a tributary to Logan River, July 1954.

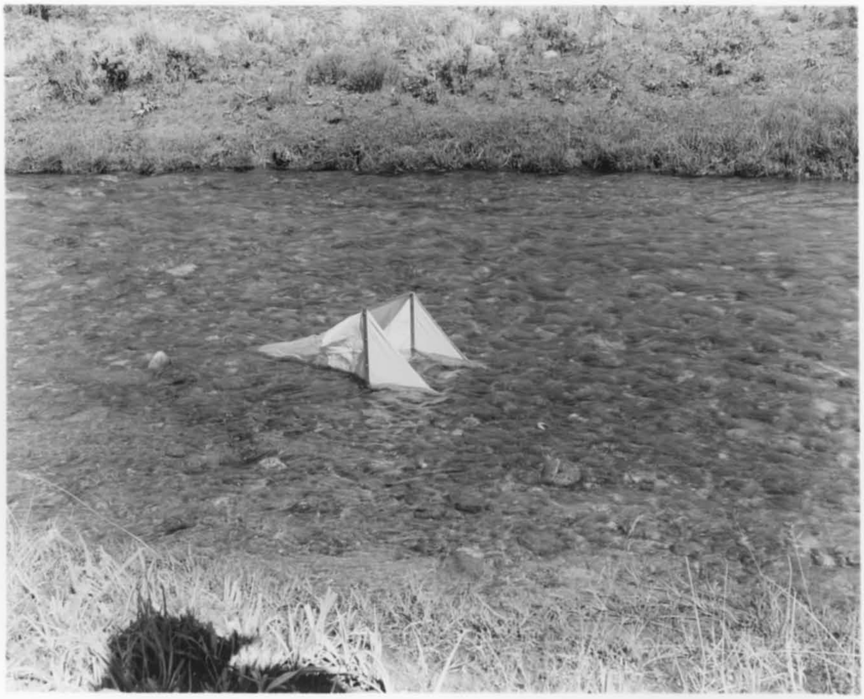


Figure 11. Temple Fork test area, number 2, July 1954.

Figure 12. Temple Fork test area, number 3, August 21, 1954.

Table 3. Estimates of occurrence of the bottom types of three stations in the Logan River, given as percent of total area

Location	Boulders	Coarse Rubble	Fine Rubble	Coarse Gravel	Fine Gravel
Tony Grove Summer Camp	63	29	6	2	1/
Number 4 Bridge	17	34	44	5	1/
DeWitt Forest Camp	2	20	338	28	12

1/ Often there is some fine gravel present between boulders but the amount is negligible.

Classification: Boulders - rocks over 12 inches.

Rubble
- Coarse - rocks 6 to 12 inches.
- Fine - rocks 1 to 6 inches.

Gravel
- Coarse - rocks 1 to 3 inches.
- Fine - rocks 0.25 to 1.0 inches.

PRESENTATION OF DATA

The data presented give the number of samples necessary to describe the mean of the bottom fauna four ways: (1) an accuracy of $\pm$ 5 percent with a risk of 1/3. (2) an accuracy of $\pm$ 10 percent with a risk of 1/3. and (3) an accuracy of $\pm$ 25 percent with a risk of 1/10, and (4) an accuracy of $\pm$ 50 percent and a risk of 1/10 (Tables 3 to 7).

Analysis for the number and volume of groups of organisms

Analyses for groups of organisms were carried out in the first three sets of samples taken at the beginning of the project (Tables 3 and 4). This includes the orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera. Other groups are not included as there were at least two occasions in each set of samples where they did not occur. At Number 4 Bridge there was one sample in which Plecoptera did not occur and one in which Diptera were not present.

Analysis for total numbers and total volume of organisms

In Tables 5 and 6 evaluations are based on the total numbers of organisms and the total volume of organisms, all groups included. Variation in samples is extremely high for Number 4 Bridge on July 1, 1954. As a result the sample size necessary to describe the mean number of organisms per square-foot with an accuracy of $\pm$ 5 percent with the risk of being wrong one-third of the time would require 715 samples. To describe the mean volume per square-foot with the same accuracy and risk would require 1,068 samples.

In all probability the number of samples needed to describe the mean of the bottom fauna would be consistently less for DeWitt division than for the other divisions if more test samples were taken. This division is the most uniform of the three studied.

Beaver Creek and Temple Fork tests

Tests were run on Beaver Creek to determine the variation in a relatively uniform bottom type. The samples were taken side by side. One set of four samples was taken on Beaver Creek and three sets of four were taken on Temple Fork (Table 7).

Table 4. Summary of sampling results for numbers of the Orders of insects given and the number of samples needed to describe the mean number of organisms with prescribed limits of accuracy and risk

Division	Date	No. of sq. ft. samples used in calculations	Mean no. organisms	Standard deviation	No. of samples needed at accuracy of ± 5% and risk of 1/3	No. of samples needed at accuracy of ± 10% and risk of 1/3	No. of samples needed at accuracy of ± 25% and risk of 1/10	No. of samples needed at accuracy of ± 50% and risk of 1/10
Tony Grove Summer Camp	12-4-53	10						
Ephemeroptera			12.4	30.46	2,413	604	279	70
Plecoptera			7.9	10.00	641	161	74	19
Trichoptera			87.1	72.75	280	70	33	10
Diptera			12.0	8.73	212	53	25	8
DeWitt Forest Camp	1-28-54	6						
Ephemeroptera			34.8	20.73	142	36	17	6
Plecoptera			4.3	2.88	177	45	21	7
Trichoptera			19.5	12.30	160	40	19	6
Diptera			6.5	3.68	129	33	15	5
Number 4 Bridge	4-24-54	5						
Ephemeroptera			25.4	21.52	286	72	34	9
Plecoptera			10.0	8.52	291	73	34	9
Trichoptera			57.6	36.50	161	41	19	6
Diptera			9.0	5.52	151	33	18	6

Table 5. Summary of sampling results for volume of the Orders of insects given and the number of samples needed to describe the mean volume of organisms with prescribed limits of accuracy

Division	Date	No. of sq. ft. samples used in calculations	Mean vol. organisms	Standard deviation	No. of samples needed at accuracy of ± 5% and risk of 1/3	No. of samples needed at accuracy of ± 10% and risk of 1/3	No. of samples needed at accuracy of ± 25% and risk of 1/10	No. of samples needed at accuracy of ± 50% and risk of 1/10
Tony Grove Summer Camp	12-4-53	10						
Ephemeroptera			0.152	0.2205	842	211	98	25
Plecoptera			0.124	0.0987	244	64	30	9
Trichoptera			0.690	0.7270	439	111	52	13
DeWitt Forest Camp	1-24-54	6						
Ephemeroptera			0.108	0.0492	83	21	10	4
Plecoptera			0.170	0.1319	241	58	28	8
Trichoptera			0.128	0.110	295	74	35	10
Number 4 Bridge	4-24-54	5						
Ephemeroptera			0.164	0.1463	319	80	37	10
Plecoptera			0.640	0.767	575	144	67	17
Trichoptera			0.520	0.133	27	7	4	2

Table 6. Summary of sampling results for total numbers of organisms and the numbers of samples needed to describe the mean of the total numbers of organisms with prescribed limits of accuracy and risk

Division	Date	No. of sq. ft. samples used in calculations	Mean no. organisms	Standard deviation	No. of samples needed at accuracy of $\pm$ 5% and risk of 1/3	No. of samples needed at accuracy of $\pm$ 10% and risk of 1/3	No. of samples needed at accuracy of $\pm$ 25% and risk of 1/10	No. of samples needed at accuracy of $\pm$ 50% and risk of 1/10
Tony Grove Summer Camp	12-4-53	10	127.90	92.39	209	51	25	8
	6-1-54	8	76.29	16.73	20	5	3	2
	6-21-54	8	31.25	22.23	203	48	24	7
	7-7-54	8	47.62	31.96	180	46	21	7
Number 4 Bridge	4-24-54	5	106.60	62.82	139	35	17	5
	6-22-54	5	29.68	23.89	270	65	30	9
	7-1-54	8	39.25	52.46	715	180	95	20
DeWitt Forest Camp	1-28-54	6	66.00	29.06	78	20	9	4
	3-28-54	5	98.80	22.62	21	7	4	2
	7-8-54	8	33.87	17.58	107	26	13	5

Table 7. Summary of sampling results for total volume of organisms and the numbers of samples needed to describe the mean of the total numbers of organisms with prescribed limits of accuracy and risk

Division	Date	No. of sq. ft. samples used in calculations	Mean vol. organisms	Standard deviation	No. of samples needed at accuracy of ± 5% and risk of 1/3	No. of samples needed at accuracy of ± 10% and risk of 1/3	No. of samples needed at accuracy of ± 25% and risk of 1/10	No. of samples needed at accuracy of ± 50% and risk of 1/10
Tony Grove	12-4-53	10	1.08	0.947	310	77	77	10
Summer Camp	6-1-54	8	0.0971	0.097	403	100	47	12
	6-21-54	8	0.259	0.258	399	100	46	12
	7-7-54	8	0.419	0.270	167	42	20	7
Number 4 Bridge	4-24-54	5	1.560	1.306	277	71	33	10
	6-22-54	5	0.250	0.071	32	9	4	2
	7-1-54	8	0.556	0.909	1,068	268	124	31
DeWitt Forest Camp	1-28-54	6	0.605	0.299	98	25	12	5
	3-20-54	5	0.694	0.093	8	3	2	2
	7-8-54	8	0.23	0.170	211	55	26	8

Table 8. Summary of sampling results for total numbers and volume of organisms, Temple Fork and Beaver Creek test areas, and the samples needed to describe the mean of the numbers and volume of organisms with prescribed accuracy and risk

Area	Date	No. of sq. ft samples used in calculations		Mean	Standard deviation	No. of samples needed at accuracy of ± 5% and risk of 1/3	No. of samples needed at accuracy of ± 10% and risk of 1/3	No. of samples needed at accuracy of ± 25% and risk of 1/10	No. of samples needed at accuracy of ± 50% and risk of 1/10
Temple Fork									
1.	6-14-54	4	Numbers	55.25	39.27	203	52	24	7
			Volume	0.522	0.514	389	217	10	4
Beaver Creek									
1.	6-15-54	4	Numbers	78.75	56.66	207	51	24	7
			Volume	1.37	0.625	84	98	45	12
2.	8-19-54	4	Numbers	100.00	24.20	24	7	4	2
			Volume	2.02	.912	82	21	10	4
3.	9-21-54	4	Numbers	67.75	9.18	8	3	2	2
			Volume	0.80	0.475	141	36	17	6

DISCUSSION

At the outset of any study of availability of fish food, two things must be decided upon: (1) the accuracy with which the mean is to be described; and (2) the risk or the amount of times the worker is willing to be wrong in making this description of the mean. An accuracy describing the mean for the samples is given at $\pm$ 5 percent and $\pm$ 10 percent with the risk of being wrong 1/3 of the time, and an accuracy of $\pm$ 25 percent and $\pm$ 50 percent with the risk of being wrong 1/10 of the time (Tables 3 to 7).

The data indicate that by decreasing the accuracy by one-half, the sample size is decreased by approximately one-fourth. Using the calculated sample sizes for Tony Grove Summer Camp, December 4, 1953, (Table 6) for example, the number of samples necessary to describe the mean with an accuracy of $\pm$ 10 percent ($N = 51$) is near one-fourth of the value of the number necessary with an accuracy of $\pm$ 5 percent ($N = 209$).

If the risk is decreased from 1/3 to 1/10, the number of samples is increased somewhere near three times. In the above example where the number of samples needed is 209 with accuracy of $\pm$ 5 percent and a risk of 1/3, if the risk were changed to 1/10 the number of samples is 610.

In making a study of a stream with a bottom type similar to DeWitt Forest Camp Division, an accuracy of $\pm$ 25 percent with the risk of being wrong as little as 1/10 of the time would probably be the best that could be obtained. Greater accuracy and less risk would require too many samples to be practical. A description with less accuracy or greater risk would be of doubtful value. For an intensive study, at this accuracy and risk, the number of samples necessary may not be prohibitive in many streams. Probably for fishery survey work, the number of samples needed for describing the mean would be out of the practical range of sampling. An accuracy of $\pm$ 50 percent is such a wide interval that little information is gained by using it.

Especially apparent in Logan River are the areas that cannot be sampled by present methods due to the torrential rapids and boulders. The stream divisions used in the study were chosen for their presumably uniform characteristics which made sampling appear possible. Even here, the variation is extremely high. Obviously, it would be fallacious to say that these areas represented the entire river. This would also apply to the Beaver Creek and Temple Fork test areas, where the bottom types are quite uniform. These small areas were hardly characteristic of the bottom type in these streams.

The formula used in determining the number of square-foot samples may also be used to determine the accuracy at a given risk when the number of samples, the mean, and the standard deviation of the mean are known. Using the set of samples taken July 8, 1954, at Tony Grove Summer Camp, Table 6, supposing the accuracy of the mean is wanted with the risk of being wrong 1/10 of the time. Using the formula:

$$\sqrt{N} = \frac{t\ s}{a\ (\bar{X})} \quad \text{and solving for a}$$

$$a = \frac{-t\ s}{\sqrt{N}\ (\bar{X})} = \frac{1.86\ (.27)}{8\ (.419)} = 0.43 \ .$$

Thus, if a worker takes a set of samples, he is able to determine just what accuracy the samples give him in describing the mean. This will also serve to point out the fallacy of using three or four samples to describe a section of a stream, as has often been done.

The great variation found in streams is due to a variety of micro-habitats. The species and number of organisms vary with the size and shape of the rocks, the current, and possibly with the depth. Tests in Bear Lake indicate the variation is not as great in that body of water.[1]

Since most organisms dealt with in this study are relatively small, one large organism can change the volume considerably. This, in turn, increases the variance of the mean. This occurred in test 3 in Temple Fork (Table 8). One Tipulid larva increased the number of samples necessary to describe the mean of the bottom fauna from what would have been below 10 at any degree of accuracy and risks given in tables 3 to 8, to as high as 141 at an accuracy of $\pm$ 5 percent and a risk of 1/3.

Although it is extremely difficult to adequately represent the populations of organisms, it may be possible to follow changes in composition and gain a fairly good estimate of differences from time to time.

At present there seems to be no quantitative method of sampling stream bottom fauna that gives desired accuracy with a reasonable number of observations. However, research should be continued on the methods of measuring the availability of fish food. Work should be done in other areas to determine whether or not the same conditions exist elsewhere as in Logan River.

Further study should be made on the dragnet described by Usinger and Needham (1954). They say an index of the bottom fauna can be determined with this device. Another possibility that should be completely explored is the use of the drift net for measuring food

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1. Information furnished by Earl W. Smart who is, at present, studying the bottom fauna in Bear Lake, Utah and Idaho.

availability. Some preliminary work was done in Logan River, though not enough to draw any specific conclusions (Appendix and Appendix Table 1).

SUMMARY

Little information is available concerning the number of square-foot samples necessary to describe the mean of stream bottom fauna within definite limits. Sampling requires considerable time and money; and since the species composition, number, and volume of bottom fauna can change within a short time interval, it is necessary to know the minimum number of square-foot samples needed for a given accuracy at a given risk of being wrong. This level of accuracy and risk must be decided upon by the biologist.

Study areas were located in Logan River and two of its tributaries, Beaver Creek and Temple Fork, in Cache National Forest, northern Utah. These divisions were laid out in Logan River: (1) Tony Grove Summer Camp, (2) Number 4 Bridge, and (3) at the east end of DeWitt Forest Camp. Each division was made up of 50 experimental units. Each experimental unit contained 10 sampling sections. For sampling, the experimental units and the sampling section were both drawn at random. Analyses were carried out on both number and volume of organisms to determine the mean, standard deviation, and the number of square-foot samples necessary to describe the mean with an accuracy of $\pm$ 5 percent and $\pm$ 10 percent with the risk of being wrong 1/3 of the time; and an accuracy of $\pm$ 25 percent and $\pm$ 50 percent with the risk of being wrong 1/10 of the time.

The following general formula was used to determine the number of samples necessary to describe the mean number or volume of organisms:

$$\sqrt{N} = \frac{t\ s}{a\ (\bar{X})}$$

where:

N is the number of samples necessary to describe the mean with a given accuracy and a given risk.

t is the approximate value for a given risk taken from a standard table for the percentage points of the t-distribution.

s is the standard deviation of the mean.

a is the given percent of accuracy desired in describing the mean.

$\bar{X}$ is the mean number or volume of organisms.

Data indicate that an accuracy of $\pm$ 25 percent with the risk of being wrong 1/10 of the time is probably the best description obtainable in uniform areas similar to the DeWitt Forest Camp Division. Greater accuracy and/or less risk would require too many samples to be practical. In most of Logan River even this inaccurate description may require too many samples. More research should be done to determine whether the same problem of sampling Logan River exists elsewhere.

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APPENDIX

THE DRIFT NET

<u>Description of study area</u>

The drift net experiment was conducted at DeWitt Forest Camp, Logan Canyon. The stream narrows to about 20 feet in this section. The water is swift and between 14 and 16 inches in depth. The bottom type is largely boulders and coarse rubble. This section of stream lies approximately 150 yards downstream from the DeWitt Forest Camp stream Division (cited page 16).

<u>Description and use of the drift net</u>

Figures 13 and 14 are photographs of the drift net used in this preliminary experiment. The mouth of the net is one foot square. The tapering sides are of bronze door screen, 18 mesh per inch. The bucket is a converted automotive oil filter housing whose sides are also screened. This bucket has the advantage of being easily removed and replaced. Mounting brackets are placed in the mouth of the net to hold a current meter. An Atlas current meter was used in this experiment. The meter directly records the number of revolutions of the propeller. When the meter is calibrated in feet per second per revolution, the amount of water passing through the net in a given time can readily be determined. From this the number of organisms can be determined in terms of the volume of water flowing through the net.

The net is anchored by chains extending from each side of the net. These chains are fastened to posts set in front and to the side of the place in which the net is to be set.

Organisms are evaluated numerically and volumetrically. Volume is measured by the water displacement.

Conclusions

The data from the drift net experiment are unsufficient to draw any specific conclusions. At present calibration of the meter is not completed. For this reason revolutions of the meter rather than cubic feet of water are given (Appendix Table 1).

It is noted that the revolutions for approximately the same time interval vary considerably. This variation is largely due to the net clogging with algae and debris. Stream fluctuations and turbulence have also been suggested for this variation. These are probably not the principle causes. As the temperature was rarely above 25° F. during the time of the experiment, the stream should not have fluctuated to any extent. Variations due to turbulence should even out over long sets as were used in this experiment.

The variation may possibly be reduced if the net sets were shorter and if the nets were scrubbed with a brush, rather than merely rinsing after each set. Probably the net should be designed similar to a Wisconsin plankton net described by Welch (1948, p. 239). This design would decrease back pressure and reduce clogging.

Appendix Figure 1. Side view of the drift net with an Atlas current meter in the foreground.

Appendix Figure 2. Front view of the drift net showing the Atlas current meter mounted.

Appendix Table 1. Results of each set in the drift net experiment in Logan River

Date	Time interval	Total hours	Cubic Centimeters of organisms	Total meter revolutions	Total number of organisms	Organisms per thousand revolutions
1-24-55	10:15-17:40	7.2	trace	36,219	26	0.72
1-25-55	18:00-6:5	12.1	0.7	26,424	33	1.25
	6:20-17:20	11.1	0.1	36,260	11	0.32
1-26-55	17:40-6:05	12.4	0.3	16,440	31	1.89
	6:15-17:20	11.1	0.3	31,630	35	1.11
1-27-55	17:30-6:10	12.7	0.7	13,124	18	1.37
	6:20-17:50	11.5	1.4	21,916	19	0.91
1-28-55	18:00-6:40	12.7	0.1	8,190	12	1.46
	6:45-17:40	10.6	0.1	29,670	13	0.44